Waste Water Treatment and Recycling
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Lecture – 55
Wastewater Reuse and Recycling Regulatory Guidelines

Hello everyone, and welcome to this weeks' 4th class, which is where we are basically discussing about the wastewater reuse and recycling aspect ok. So, in the previous lectures of this week we have talked about the different aspects of the wastewater reuse and recycling; starting from it is basic concept, and then what are the various types of the reuse, what are the opportunities for reuse purpose, what is the scope where we can kind of reuse the or reuse or recycle the waste water and those certain aspects that we discussed.

So, this class we are going to talk about the regulatory guidelines, which is one of the very important aspects when we think of reusing the wastewater. So, that we are going to discuss in this class.

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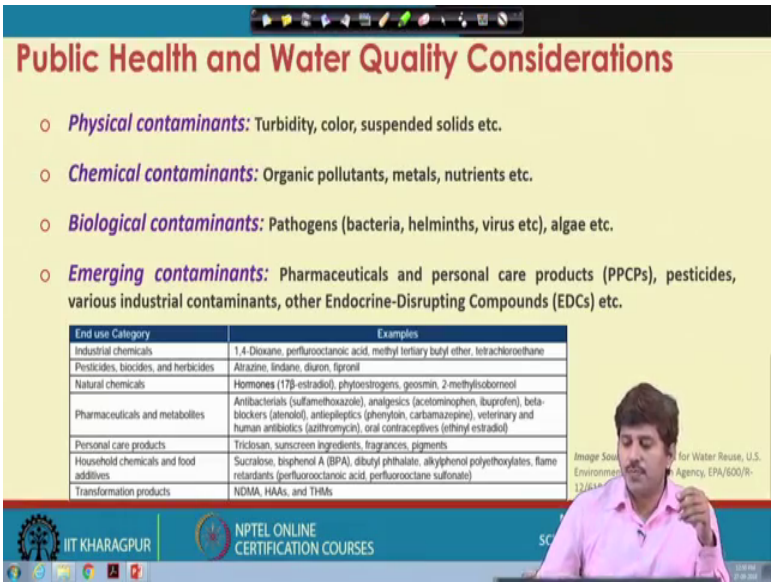

So, while we go for the reuse purpose or we recycling purpose of the wastewater, the major criteria or the most important aspect is to ensure that public health safety ok. And for the public health safety, we must understand that when we put water like when we withdraw water from natural resources process it and supply it. So, the water available in

our natural resources are supposingly of like fairly good quality without too much of kind of pollutants which can cause severe health risk. But in the wastewater, because it is a used water there has been lot of pollutants added from the households or if it is industrial wastewater from industrial sector.

So, because of this inherent availability of the various contaminants or various pollutants in the wastewater, there is a much superior degree of health risk. And for the treatment aspects that we see, so our secondary treatment does not target removing of all those contaminants ok. We may go for advanced treatment, but for that purpose also we have to have the idea or detection of what kind of contaminants are present in the wastewater.

So, if we see those considerations of the different types of water quality consideration. So, there is physical water quality consideration or physical contamination which is due to the physical contaminants which could involve (Refer Time: 02:49) color suspended solids etcetera. Then there are chemical contamination in the form of organic pollutant, metal, nutrients, biological contaminants which are pathogens and could be algae or those kind of thing.

So, up to these are pretty ok, people know that these will be the present in the wastewater and they provide adequate degree of treatment if they plan to for reuse or recycling purpose that is done. The most threatening or most dangerous is the emerging contaminants, because the emerging contaminants are the compounds which has not been traditionally liked detected or formulated. So there are not many reuse guidelines on these emerging contaminants ok.

And people generally do not go for testing these at first place. So, if you are not testing that your wastewater does it have pharmaceutical or personal care products, does your wastewater has pesticides in it? Does your wastewater has say various industrial contaminants? There are many endocrine disrupting compounds, so are some of them present in the wastewater.

So, if we are not tasting that at first place. So, we do not know if there are emerging contaminants exist or not and probably we will end up supplying a water saying that it is not having BOD, it is not having cod it is not having suspended solids the dissolved solids are also not too much ok, all within the permissible limit. But if you have not tasted for these emerging contaminants at the first place, your mud water may not be safe

for the reuse purpose. So, that is how the public health security is becomes much more privalent with the recycled or treated waste water supplies or reuse options as opposed to the raw water reuse systems, ok.

So, depending on the end use category, there are like various examples of the emerging contaminants or the newer pollutants which are coming these days. So, in industrial chemicals we can have dioxins, we can have kind of various tetra chloromethane or those kinds of things. Then there are there is possibility of pesticides, biocides and herbicides coming in ok. So, atrazine lindane chlorpyrifos and us alpha and those kinds of compounds could be present. There are natural chemicals, so various hormones ok the growth promoters wait this thing.

So, there are like quite a few those kind of things can is can be possible. There are various pharmaceuticals and metabolites in the form of say antibiotics and algae sakes, then beta blockers so anti allergics so then oral contraceptives. So, there are like variety of these things can also be present. There are various personal care products ok.

So, a lot of cosmetic comes under this category fragrances, cosmetics, pigments those kind of thing. There are variety of household chemicals and food additives ok. So, again quite a few food additives are being used in these days by people, and various transformation products. So, the original products when they get transformed in presenting in the water through hydrolysis or those kind of systems, so they may be like trihalomethanes, (Refer Time: 06:25) acids. So, those kinds of things could be present in the water.

So, they are the kind of things that are most crucial, and that is why when we go for reuse, quality, characterization, or reuse quality standard, we must think of the potential risk that these compounds could cause. And the chances of these compounds being present based on the point or the source of the wastewater that we are discussing with. So, if our source of wastewater is industrial wastewater, then there is a like significant chances of some of these being present over there, ok.

So, that is what is the basically one of the important aspect that one must consider while going for the wastewater reuse purpose.

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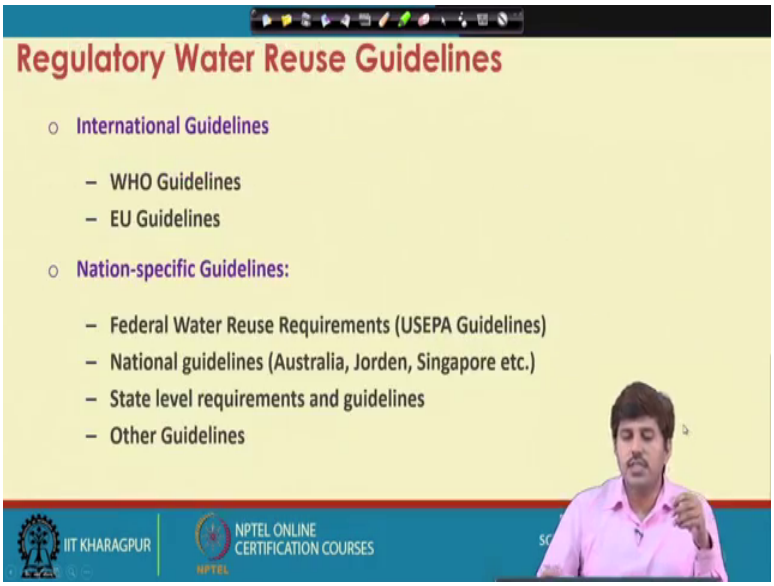

So, if we see that regulatory reuse guidelines. So, there are international guidelines, and there are various countries specific guidelines or nation specific guidelines. So, in international guidelines like we have agencies such as WHO which releases it is guidelines. There are European Union which may which has it is own like reuse guidelines. There are nation is specific, so for different countries, there are different guidelines, it is not available for all countries. So, like India does not have a reused specific guidelines as of now. So, like the discussions are on and people are like saying that we should have we must have a reuse water reuse quality standards, but as of now it does not exist.

So, but there are various countries that have like the there are guidelines from Australia, Jordan, Turkey those kind of countries does have their own guidelines. US of course, has so federal water reuse requirements or USEPA has it is own guidelines. There are state level requirement and guidelines also they are in the various states in a nations; like in Australia, we have guidelines from Victoria, guidelines from South Australia. In US we have say the like California has it is own guidelines. So, there are variety like the different states could have their own requirements, their own recommendations, and their own guidelines for which because water being a state subject.

So, they can like the different states can come up with their own guidelines also, at many places. There is possibility of other guidelines for some even the municipal state systems

could make those guidelines, revise those guidelines make them more stringent or more relaxed or make more situation specific.

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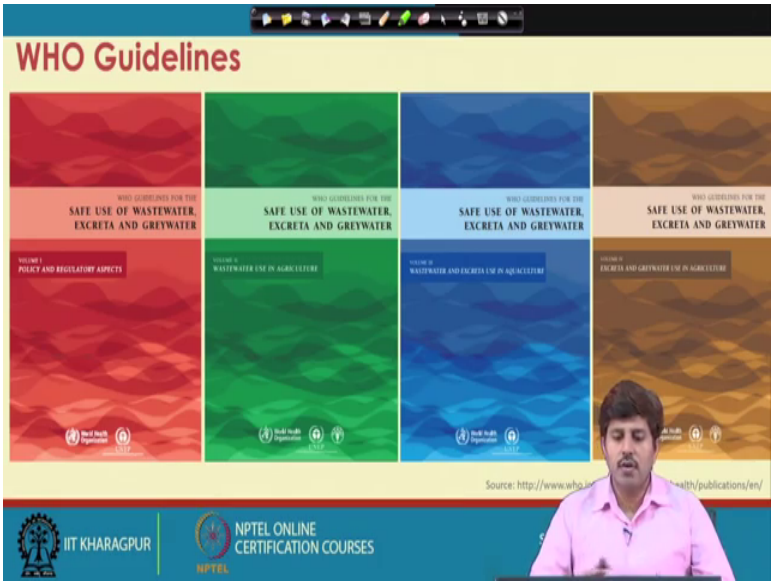

So, if we see the who guidelines, WHO has kind of a like they prepare a 4 volume manual on these guidelines for safe use of wastewater excreta and gray water so that there were the 4 volumes of this was released which are available online. And the volume one dealt with the policy and regulatory aspect. Volume 2 dealt with the waste water use in agriculture. Volume 3 was waste water and excreta used in aquaculture, whereas, volume 4 excreta and gray water used in agriculture. So, these were the 4 different volumes which kind of in detail almost each of these are for over 200 pages.

So, they in kind of detailed explained and summarize the various potentials, risk associated, reuse, aspects in all these 4 different volumes From the WHO.

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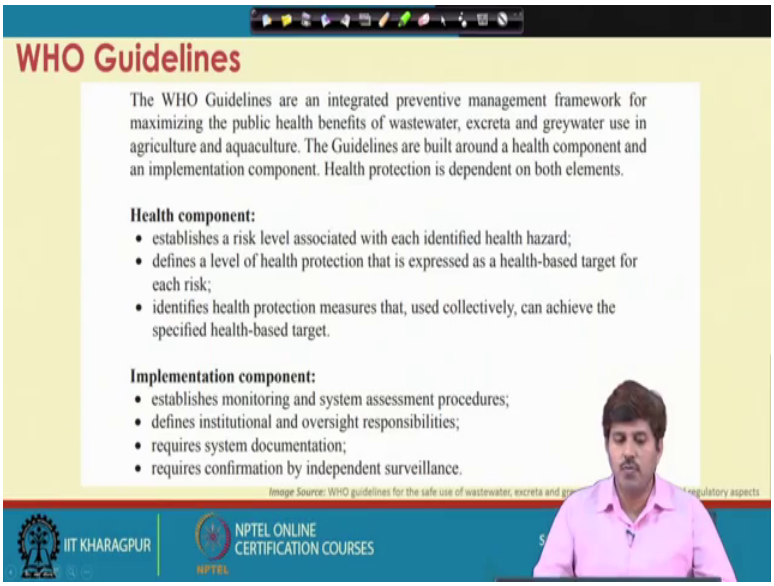

So, this who guidelines essentially are kind of integrated preventive management framework for maximizing the public health benefits of the wastewater; excreta and gray water uses in the agricultural and aquaculture. The guidelines are built around a health component and implementation component so there are like there are health components.

So, risk associated or how to establish those risk, how to ascertain that these risks are minimized. So, all those are described in quite detail in these guidelines. And there are then implementation components. So, how to implement these systems for the reuse or potential reuse in the agriculture and aquaculture those kind of systems, which are the prime focus for these who guidelines? So, health protection is dependent on both the elements; so, health component kind of talks about establishing a risk level between the associated with each and identified health hazard.

So, what is the risk associated with the different health hazards that are there. And then it also defines a level of health protection. That is expressed as a health based target for each risk. Then it identifies this health protection measures. So, what different measures we can adopt collectively say for protecting this health ok. So, that way the idea is to achieve the specific health based targets.

And then in the implementation components, it stablishes monitoring and system assessment procedure. So, how to monitor these like this effectiveness of these systems and the risk arising of these systems, then it also defines the institutional and oversight

responsibilities. So how these different institutions can actually be made responsible for the different tasks ok, what how the responsibilities can be shared or distributed among the different stakeholders, different institutions looking after the case.

It requires system documentation, so what kind of system documentation is required is explained in this in implementation component. And it also explains the requirement of the confirmation by the independent surveillance. So, there has to be like, it is not because mostly it is water is a state subject. So, the government are responsible for looking after taking after these things or even if it is let us say outsourced to some agency.

So, there has to be independent surveillance also in order to make extra sure that the risks are minimized and things are being implemented in fair and proper manner.

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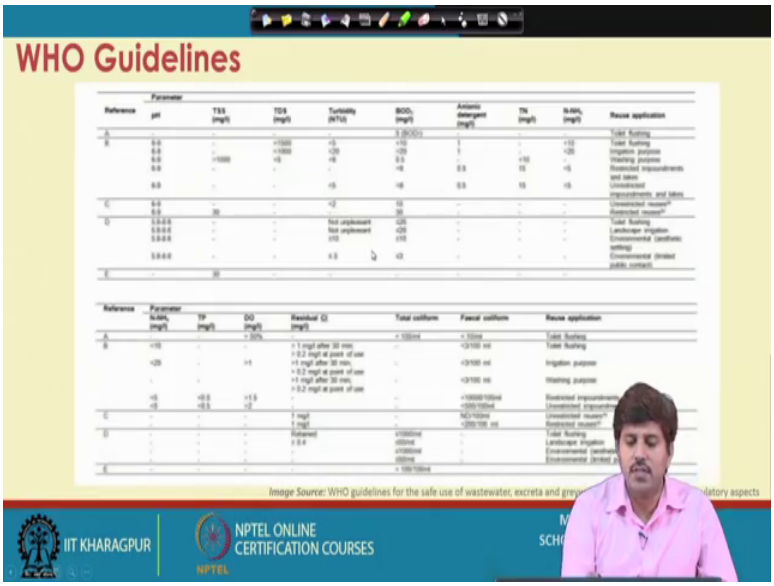

So, this is another like kind of who guidelines for different type of reuses. So, what are the criteria for pH, TSS, TDS, turbidity, BOD those kinds of things. So, I am sorry that numbers might not be apparently visible, but it is the idea is that there. There are certain systems exist which can be used for the purpose of seeing that to what scale treatment is needed based on my target reuse criterias.

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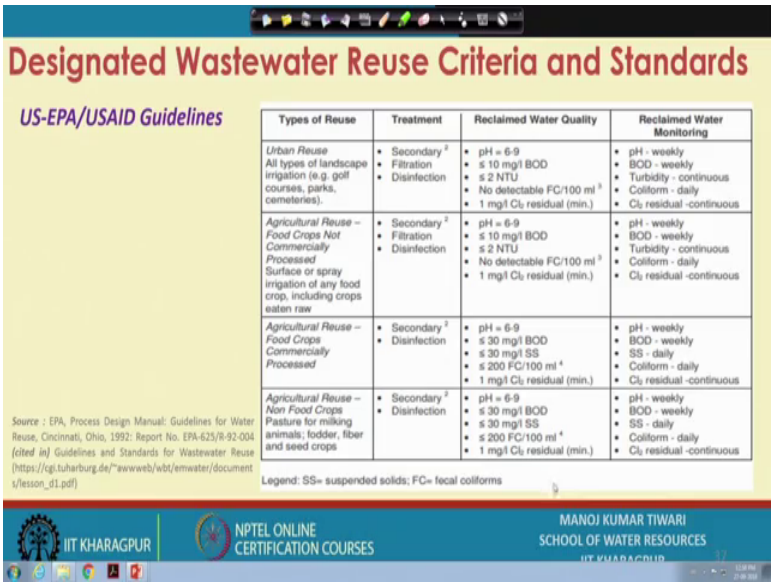

So, if we say the designated wastewater reuse criterias and standards on from USEPA or USAID guidelines if we see.

So, they are depending on the type of reuse again if it is for urban reuse. So, the degree of treatment needed secondary filtration and disinfection, the reclaimed water quality should actually be meeting this. And we need to regular monitoring of the like weekly monitoring of the pH, BOD turbidity should be continuously monitored, chlorine residual should be continuously monitored and coliform or pathogen monitoring should be on a daily scale ok. If it is being used for say, agricultural reuse, for food crops not commercially processed; so food crops that are not commercially processed.

So, there were secondary filtration secondary stage treatment filtration and disinfection is needed. And this is the kind of like the claimed water quality it should meet these qualities. So, pH should be somewhere between 6 to 9. The BOD should be less than 10 milligram per liter. Turbidity should be less than 2 ntu. There should not be fecal coliform detected ok. And the residual chlorine should be one milligram per liter minimum.

Again we need to monitor these so coliform on daily scale and those few parameters on weekly or continuous scale. Then if it is for agricultural use for food crops which are commercially processed. So, again we need to go for secondary and disinfection level treatments, this is the minimum requirements ok, and these are the monitoring

requirements. And if it is being used for non food crops in agricultural. So, again we will need secondary and disinfect secondary treatment and disinfection with these water quality criterias and these are the monitoring requirements. So, that way we have these different like criterias and requirement for monitoring.

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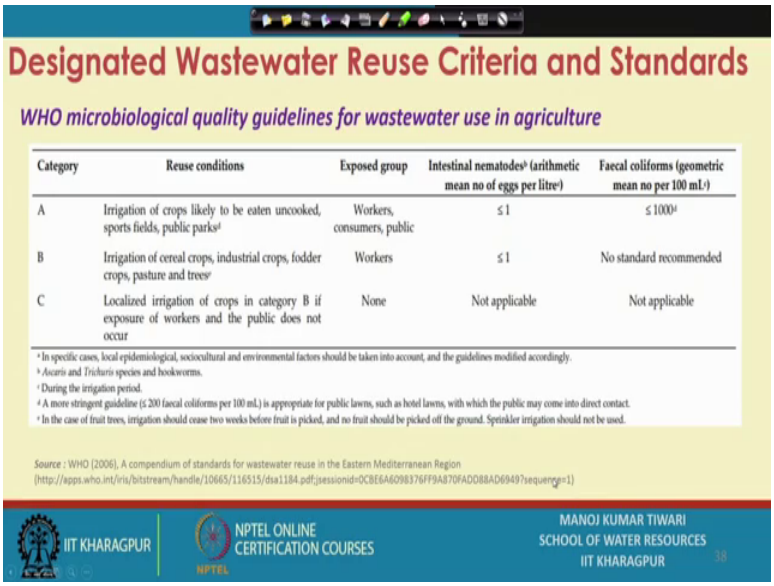

So, who has another similar like guidelines for other prospective as well. So, there is a microbial quality guidelines for wastewater reuse in agriculture. So, there are 3 categories is specified by the WHO.

So, reuse condition is for irrigation crops likely to be eaten uncooked like sports field public parks those places. So, the exposed group is the basically workers consumers public ok. There has to be like the intestine nematodes measurement, so basically no eggs or litre less than 1 ok; fecal coliform less than 1000. So, this is your geometric mean. For B which is irrigation of like cereal crops, industrial crops, fodder crops, posture and trees, so workers will be exposed to this.

There is no recommended standard for this and for intestinal nematodes should be less than 1, and localized irrigation of crops in category B, if exposure of workers and public does not occur. So, if it is not there, then nobody is actually going to exposed with that, and there are no kind of these things are not applicable. So this is the recommendation from WHO, ok.

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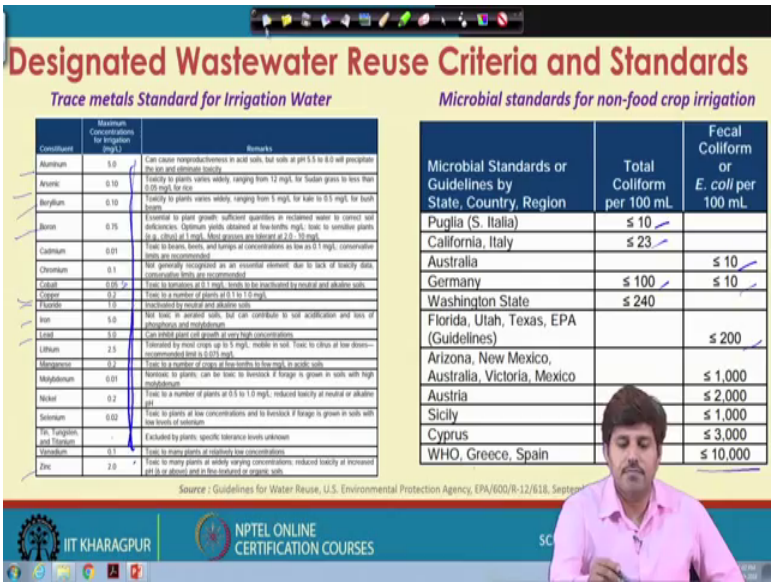

Similarly, we have say recommendation from various other agencies if like food and agricultural organization of states those places. So, like there are trace metal standards for irrigation water. So, for water being used in a irrigation, these are the standards for various trace metals. So, for say aluminum should be less than 5 milligram per liter, arsenic should be less than 0.1, beryllium less than 0.1, boron 0.75, that way zinc 2 lead could be up to 5 iron, could be up to 5 fluoride, could be up to one milligram per liter.

So, that way we have various standards for these different metals. And then of course, in what way they are kind of this thing like copper is toxic to a number of plants at concentration 0.1 to 1 milligram per liter, but still like up to 0.2 is ok. That what has been recommended. Cobalt is toxic to tomatoes at 1 0.1 milligram per liter. So, tend to be kind of inactivate by natural and alkalines soil. So, that is why it is just 0.05 is the recommended limit.

So, what kind of effect they can create that way and what is the allowable permissible maximum concentration level is mentioned over here. Similarly, if we see that kind of microbial standards for various non food crop irrigation, so then again there are different state and country. So, like from Pugalia in the Italy it is less than 10 coliform total coliform should be less than 10 ok. Fecal coliform is not mentioned over there. For California in Italy should be less than 23, Australia fecal coliform less than 10, Germany

fecal coliform less than 10 and total coliform could be less than 100 ok, in Florida it is 200.

So, WHO if you see Greece or Spain standard, it is less than 10000 ok. So, that way there are like the different standards for the different states or different countries that way.

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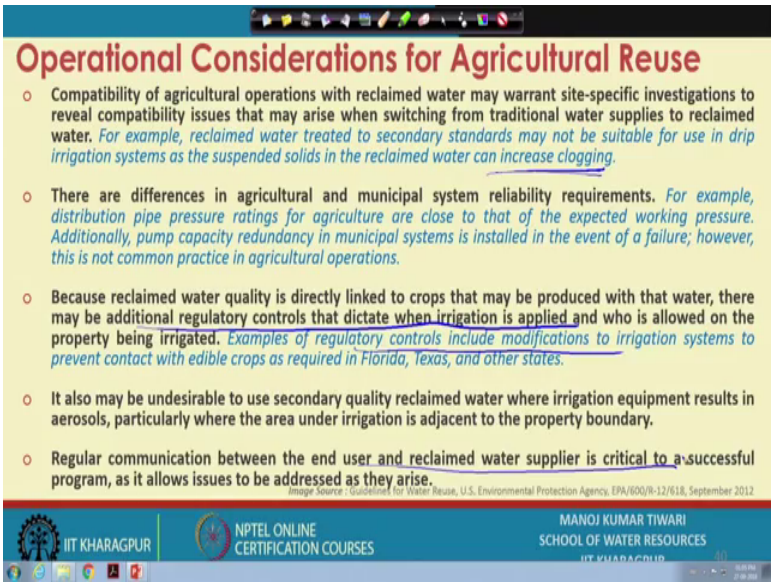

Now in agricultural sector, there are various operational considerations are also kind of thought about.

So, the like compatibility of the agricultural operation with reclaimed water may be kind of needed and may be evaluated from the site is specific investigation ok. And that is how this compatibility issues may be seen and it should be ascertained that the water supplies, like the reclaimed water which is being used is compatible for that particular agricultural operation. So, it depends again on the suitability of these things like; for example, the reclaimed water treated with the secondary level may not be suitable for a drip irrigation system ok.

So, why it may not be suitable for a drip irrigation system? Because secondary level treated water may still have certain suspended solids. So, those suspended solids can actually create problem in the drip irrigation system can block, the nozzles or those kind of thing. So, there is a high risk of increased clogging in such scenarios, and that is why

it is not recommended. There are differences in agriculture and municipal system reliability requirements as well ok.

So, for say like municipal systems are supposed to be more reliable as opposed to the agricultural system ok. So, if you are having let us say a pump, which is pumping water in a municipal system, and you get your pump fail at certain stage. So, municipal supply is going to be stopped which is totally not acceptable. So, you will have to have the backup pumps ok, installed in a municipal system, but in agricultural system it is not that essential. So, it is not that like you have to have keep extra backup pumps for pumping water in a agricultural system. So, we can sort of like see what scale or what is like what level of reliability is needed.

So, even if let us say your pump goes off for a day or couple of days, it is not that your food your crops is going to be die immediately. So, of course, you can basically arrange in between, so putting just extra pump or putting those kinds of redundant features for large amount of time unnecessary lying is not advisable because that will have associated financial cost, ok. So, further the reclaimed water quality is directly linked to the crop ok, that may be produced with that water. And that is why there are need of additional regulatory controls that detect the irrigation water that is basically being used.

So, as we have been discussing, that there needs to be regulatory controls that includes modification to the irrigation system, and prevent contact with the eatable crops particularly. Then it may also be undesirable to use secondary quality reclaimed water where irrigation equipment result in aerosols ok, again because of the issues ok. Then there are regular communication between the end user and reclaimed water supplier is critical for a successful program.

So, that user must be aware all the stakeholders must be aware with this issue. So, it allows that issues to be addressed as and when they arise in the immediate basis. So, these are some of the operational consideration.

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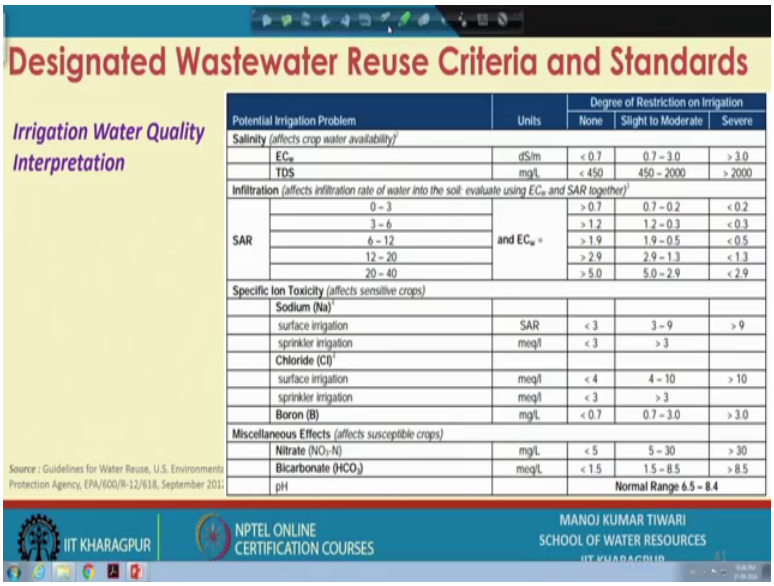

Potential Irrigation Problem		Units	Degree of Restriction on Irrigation		
			None	Slight to Moderate	Severe
Salinity *(affects crop water availability)*[2]					
	EC_w	dS/m	< 0.7	0.7 – 3.0	> 3.0
	TDS	mg/L	< 450	450 – 2000	> 2000
Infiltration *(affects infiltration rate of water into the soil. evaluate using EC_w and SAR together)*[2]					
SAR	0 – 3	and EC_w =	> 0.7	0.7 – 0.2	< 0.2
	3 – 6		> 1.2	1.2 – 0.3	< 0.3
	6 – 12		> 1.9	1.9 – 0.5	< 0.5
	12 – 20		> 2.9	2.9 – 1.3	< 1.3
	20 – 40		> 5.0	5.0 – 2.9	< 2.9
Specific Ion Toxicity *(affects sensitive crops)*					
	Sodium (Na)[3]				
	surface irrigation	SAR	< 3	3 – 9	> 9
	sprinkler irrigation	meq/l	< 3	> 3	
	Chloride (Cl)[3]				
	surface irrigation	meq/l	< 4	4 – 10	> 10
	sprinkler irrigation	meq/l	< 3	> 3	
	Boron (B)	mg/L	< 0.7	0.7 – 3.0	> 3.0
Miscellaneous Effects *(affects susceptible crops)*					
	Nitrate (NO_3-N)	mg/L	< 5	5 – 30	> 30
	Bicarbonate (HCO_3)	meq/L	< 1.5	1.5 – 8.5	> 8.5
	pH		Normal Range 6.5 – 8.4		

Now, if we see the design like designated wastewater reuse criterias and standards for other stuff.

So, for irrigation water quality interpretation ok, based on the quality of the treated water; so if let us say this is the quality of the treated water, wherever it falls we can say that how it can be used. So, if this quality is say in this range, so that water can be used without any restriction ok. It can be used anywhere, so salinity being less than 0.07 TDS being less than 450 ok. The SAR being less than 3 means m the sodium adsorption ratio that way okm chloride being less than 4 enamel equivalent per liters. So, with these nitrates less than 5m bicarbonates less than 1.5, this water can be used anywhere without any issue. If it falls in this range, so it can be basically there might be slight to moderate restrictions of using that water.

So, let us say the restriction could be in the form of that use it for only for like non-contact food crops or this kind of thing, but if it is greater than these ranges. So, there could be severe restrictions that ok, this water should be used at non-contact places or should not be used for say food crops. So, those kinds of severe restrictions can come in picture with the quality of the treated way water which is available for irrigation or reuse purpose.

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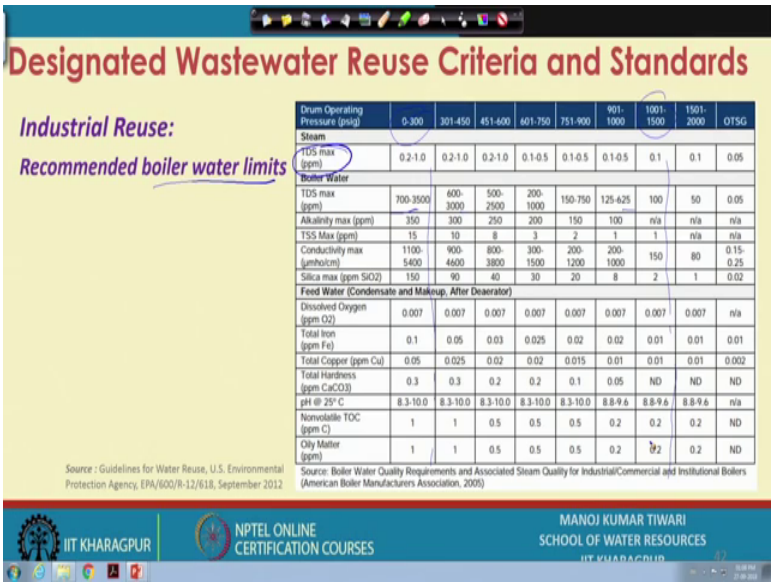

Drum Operating Pressure (psig)	0-300	301-450	451-600	601-750	751-900	901-1000	1001-1500	1501-2000	OTSG
Steam									
TDS max (ppm)	0.2-1.0	0.2-1.0	0.2-1.0	0.1-0.5	0.1-0.5	0.1-0.5	0.1	0.1	0.05
Boiler Water									
TDS max (ppm)	700-3500	600-3000	500-2500	200-1000	150-750	125-625	100	50	0.05
Alkalinity max (ppm)	350	300	250	200	150	100	n/a	n/a	n/a
TSS Max (ppm)	15	10	8	3	2	1	1	n/a	n/a
Conductivity max (µmho/cm)	1100-5400	900-4600	800-3800	300-1500	200-1200	200-1000	150	80	0.15-0.25
Silica max (ppm SiO2)	150	90	40	30	20	8	2	1	0.02
Feed Water (Condensate and Makeup, After Deaerator)									
Dissolved Oxygen (ppm O2)	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	n/a
Total Iron (ppm Fe)	0.1	0.05	0.03	0.025	0.02	0.02	0.01	0.01	0.01
Total Copper (ppm Cu)	0.05	0.025	0.02	0.02	0.015	0.01	0.01	0.01	0.002
Total Hardness (ppm CaCO3)	0.3	0.3	0.2	0.2	0.1	0.05	ND	ND	ND
pH @ 25° C	8.3-10.0	8.3-10.0	8.3-10.0	8.3-10.0	8.3-10.0	8.8-9.6	8.8-9.6	8.8-9.6	n/a
Nonvolatile TOC (ppm C)	1	1	0.5	0.5	0.5	0.2	0.2	0.2	ND
Oily Matter (ppm)	1	1	0.5	0.5	0.5	0.2	0.2	0.2	ND

There is a industrial reuse options is also there. So, for example, this is the recommended boiler water limits ok. So, if you want to put water in the boiler, the TDS is almost one of the very important criteria for boiler purpose ok. So, for boiler water the TDS has to be in this range ok, and alkalinity in this range, so again at what pressure it is being operated.

So, if it is being operated say under, you can take any like if it is operated under this pressure. So these are the criteria that should be there. If it is being operated at higher pressure, so these are the criteria it should actually meet or it should fulfill. So, that way we have kind of again as we were are just discussing that this we are not too much interested in these values, this it is just to give an idea that yes these kind of restrictions or these kind of limits or quality standards exist, and one somebody is planning for a reuse option.

So, he must ensure that the water quality that he is producing at the reclaimed water quality that is there should actually be appropriate, or should meet these regulatory requirements should be good enough for that water to be used for the designated purpose what we are discussing.

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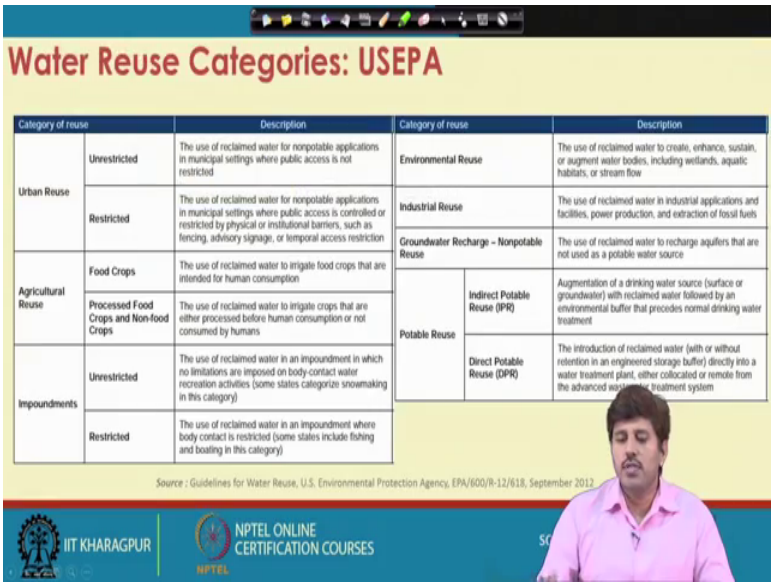

So, just a quick recap that USEPA has these different categories of the reuse.

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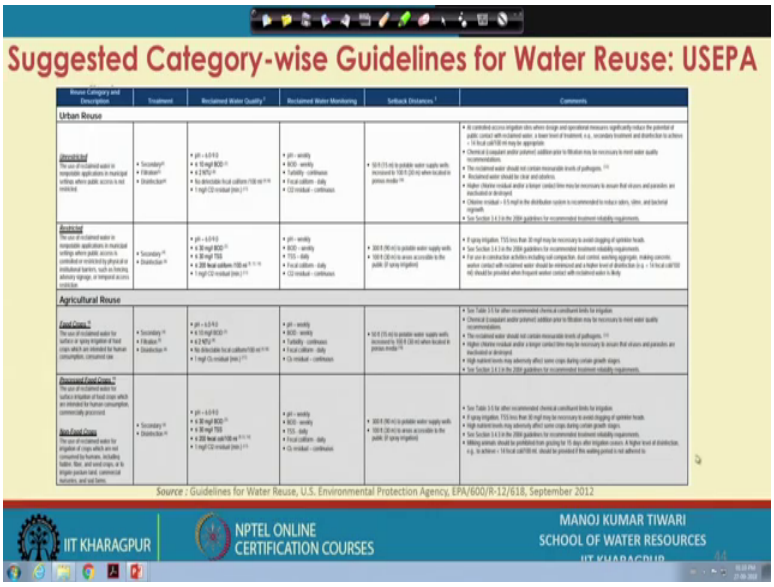

And for these differently reuse categories they have a category wise guidelines, which they have suggested, so for say urban reuse option if you see ok. So, unrestricted urban reuse option, they say that these could be the recommended treatment level and these could be the guidelines.

So, some of these as we were seeing earlier, and then what is the setback distance, means that distance minimum should be maintained this much. So, that it actually does not

affect the system in a larger run. And then there are various observations and comments over there. Similarly, for agricultural the use for food crops, these are the criteria for processed food crops non food crops these are the criterias.

So, that is about the urban and agricultural reuse.

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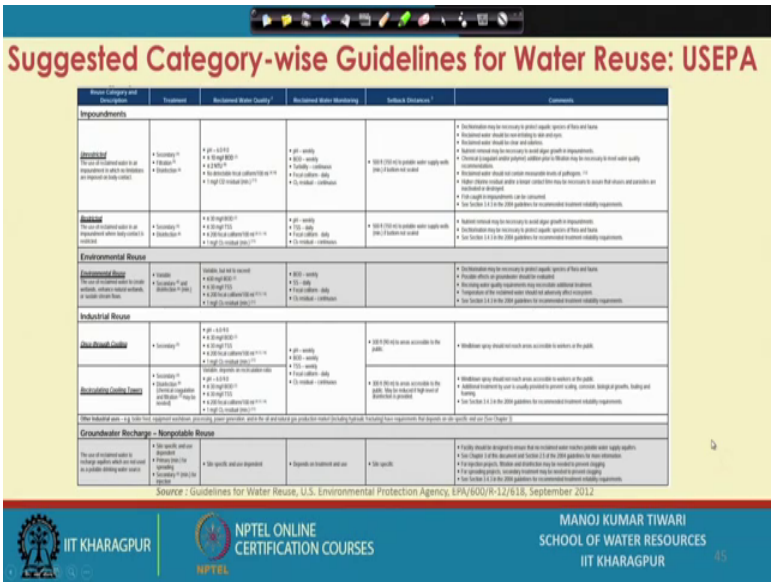

If it is going to the impoundment; so these are the again it should meet these criterias. This should be the monitoring frequency; the setback distance should be this much. For restricted impoundments, again a secondary this secondary and this. In fact, secondary level treatment and disinfection is going to be good enough. These would be the reclaimed water quality, monitoring frequencies ok, that way. For environmental reuse purpose, this is little variable as they say it is variable, but should not exceed to these limits ok. Similarly, for like the monitoring should be for BOD suspended solids fecal coliform, and chlorine residual.

For industrial reuse, so here we do not have any setback distance, because we are anyway releasing in the environment. In the industrial reuse then for cooling purpose, secondary treatment is good enough. So, we can have a relaxation for the water quality as well. Whereas, for cooling towers, recirculation cooling towers, for secondary after that we need disinfection. So, this kind of this thing and this is the monitoring. For other industrial purpose like, there are again specific requirements. For groundwater recharges

which is for non-portable uses. So, it is basically site is specific and user is specific it depends on the usage.

So, what way we want to kind of like recharge systems, which system we want to recharge it will all depend on that.

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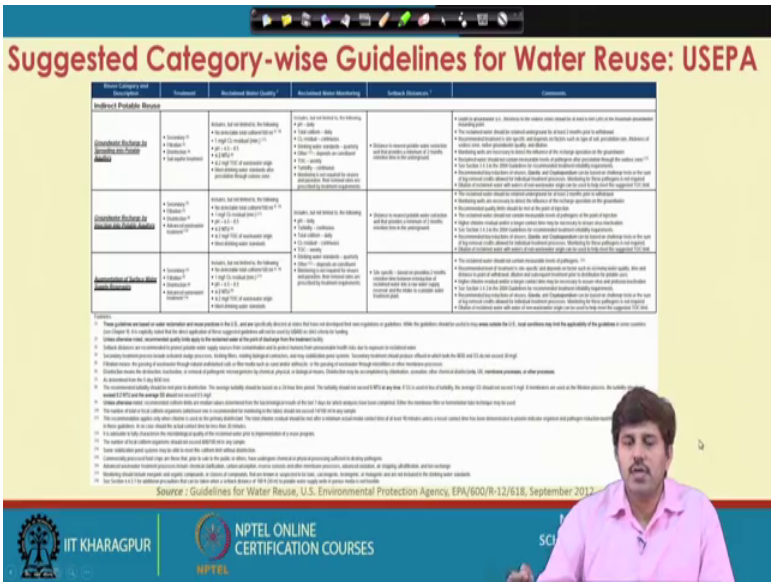

Then for the indirect portable uses ok, the IP are systems. So, it has to be basically meet these quality criterias ok. The quality criterias are going to be little more stringent there. And the reclaimed water should be monitored for variety of parameters include pH total coliform chlorine residual drinking water standards. And various other parameters including TOC turbidity and metals or those kinds of things should also be monitored ok. Same degree of monitoring is required for here if we are going for a groundwater recharge for potable aquifers, or if you are (Refer Time: 29:27) to the surface water reservoir for potable aquifers, ok.

So, this is the kind of requirement that is needed, if it is going for DPR direct portable uses. So obviously, it should meet the portable quality requirement of the portable water quality requirement or drinking water quality standards, which is applicable for each respective supply, utilities or in the different countries that different standards that are there.

So, these are the kind of standards that should be followed when we go for the when we plan for the wastewater reuse or recycling projects ok. And these standards are set based on certain criterias which kind of the major objective is to ensure the safety of human health and environment ok. So, with those ideas these standards have been set from the different regulatory agencies, and they vary actually from place to place.

So, one country may have certain standard, another country may have may be a little relaxed standards, or those kind of or maybe stringent standards. So, those things are there, but the regulatory requirements suggest and many countries do not have reuse standards like we gave the example for India. But still in those countries the direct water supply standards should be used for reuse purpose that way. So, that is about the regulatory aspects. So, these are the kind of standards that your wastewater or that the wastewater treatment facility should meet if the intended use or intended target is reuse or recycling of the wastewater.

So, we are conclude this lecture here. And then in the last lecture of this week, we will discuss the kind of some other aspect related to the waste related to the recycling ok. So, this scale of recycling and those things will be discussing in the next class.

So, see you and thank you.